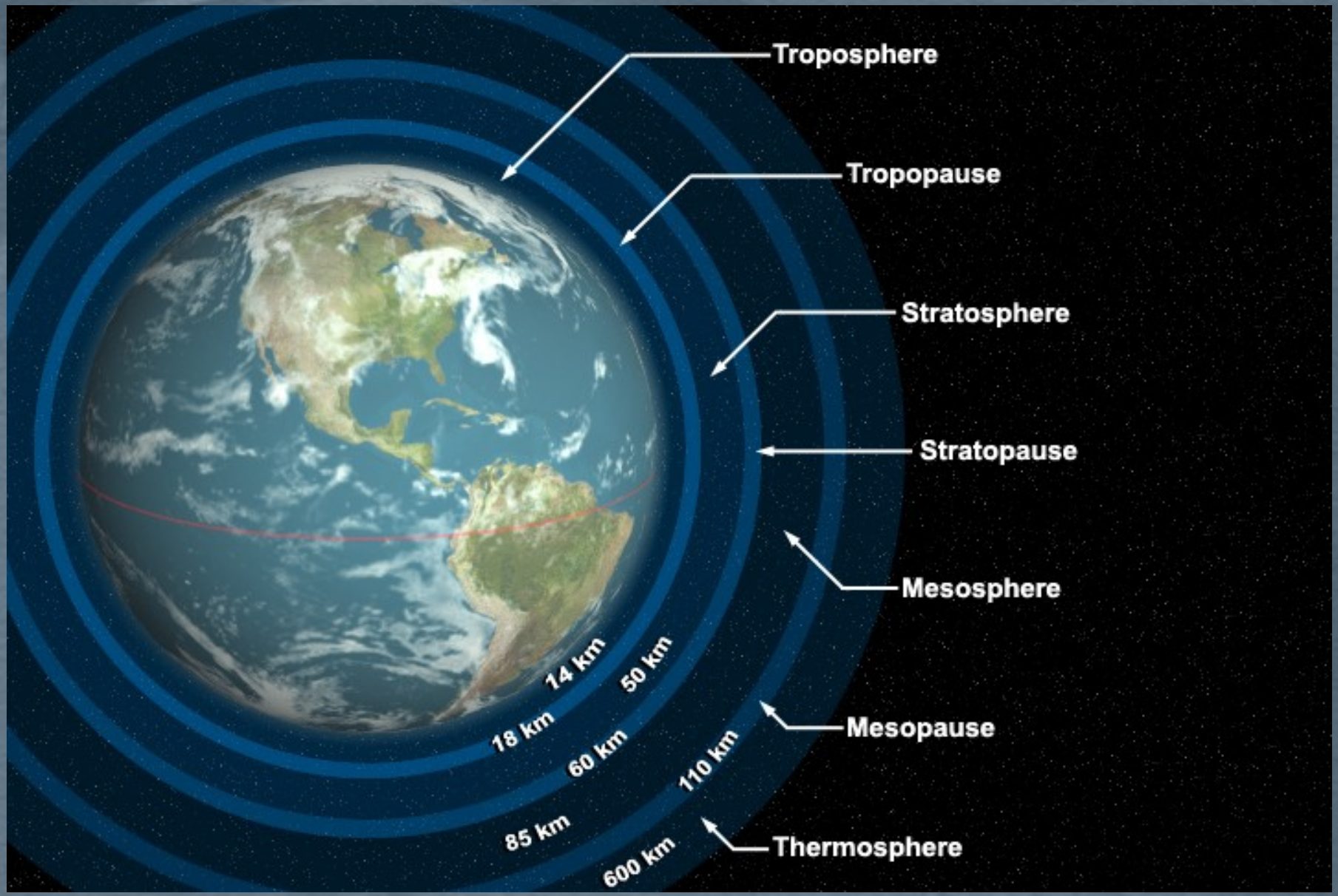
Atmospheric Physics I

2a. Determine the atmospheric structure.

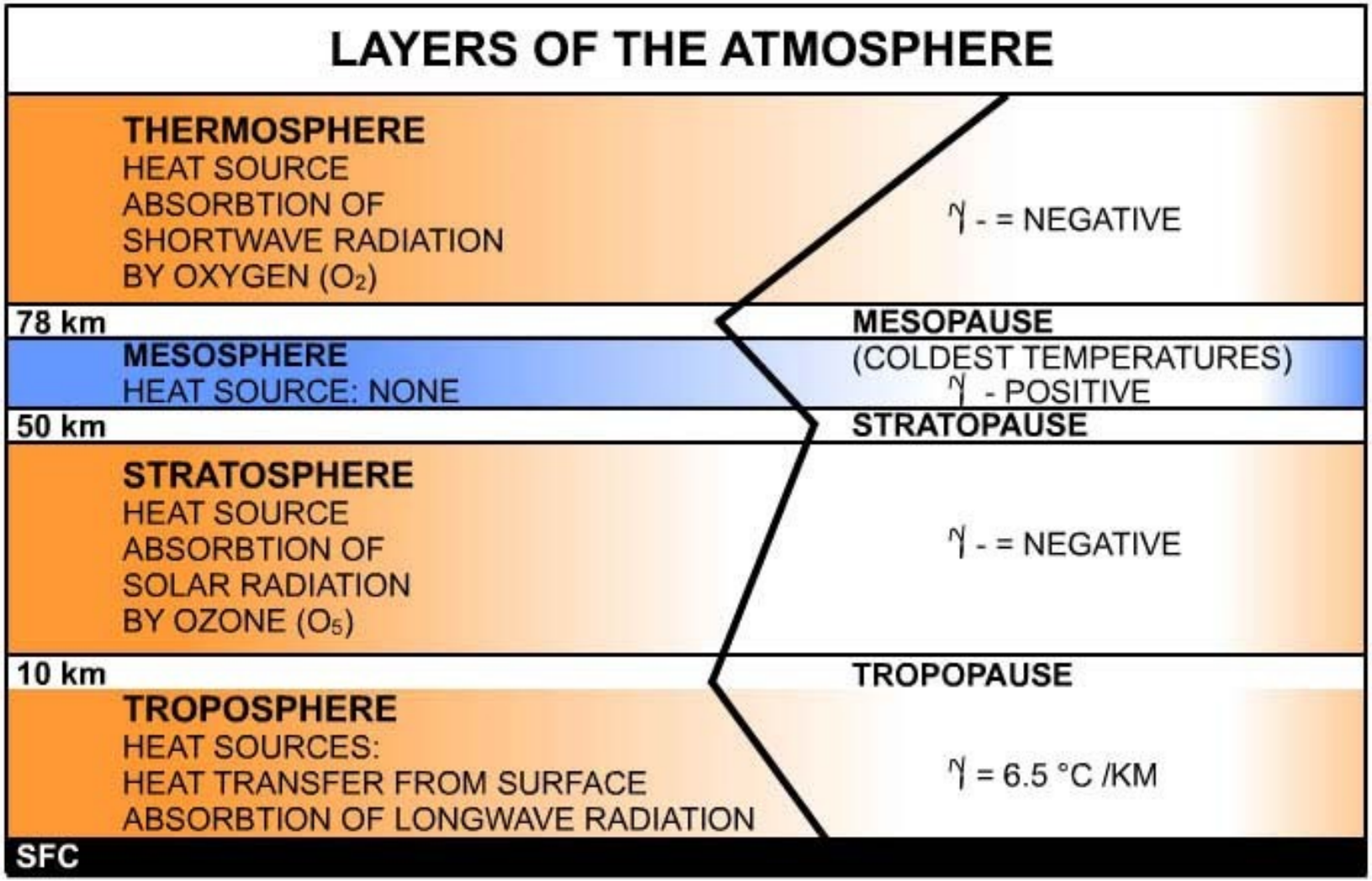
Atmospheric constituents

- Nitrogen gas - 78%
- Oxygen gas - 21%
- Inert gases - 1%
- Water vapor is highly variable from 0-4%


Troposphere
Tropopause
Stratosphere
Stratopause
Mesosphere
Mesopause
Thermosphere
14 km
18 km
50 km
60 km
85 km
110 km
600 km

Layers of the Atmosphere (Ahrens, 1999; Wallace and Hobbs, 1977)

- Troposphere - means "the changing" sphere
  - Extends from the surface to approximately 10 km.
    - Seasonal change
    - Latitude
  - Contains 80% of the atmosphere's mass.
  - Contains almost all of the water vapor, clouds and precipitation in the atmosphere.


LAYERS OF THE ATMOSPHERE
THERMOSPHERE
HEAT SOURCE
ABSORBTION OF
SHORTWAVE RADIATION
BY OXYGEN (O_2)
η - = NEGATIVE
78 km
MESOPAUSE
MESOSPHERE
HEAT SOURCE: NONE
(COLDEST TEMPERATURES)
η - POSITIVE
50 km
STRATOPAUSE
STRATOSPHERE
HEAT SOURCE
ABSORBTION OF
SOLAR RADIATION
BY OZONE (O_5)
η - = NEGATIVE
10 km
TROPOPAUSE
TROPOSPHERE
HEAT SOURCES:
HEAT TRANSFER FROM SURFACE
ABSORBTION OF LONGWAVE RADIATION
η = 6.5 °C /KM
SFC

Layers of the Atmosphere

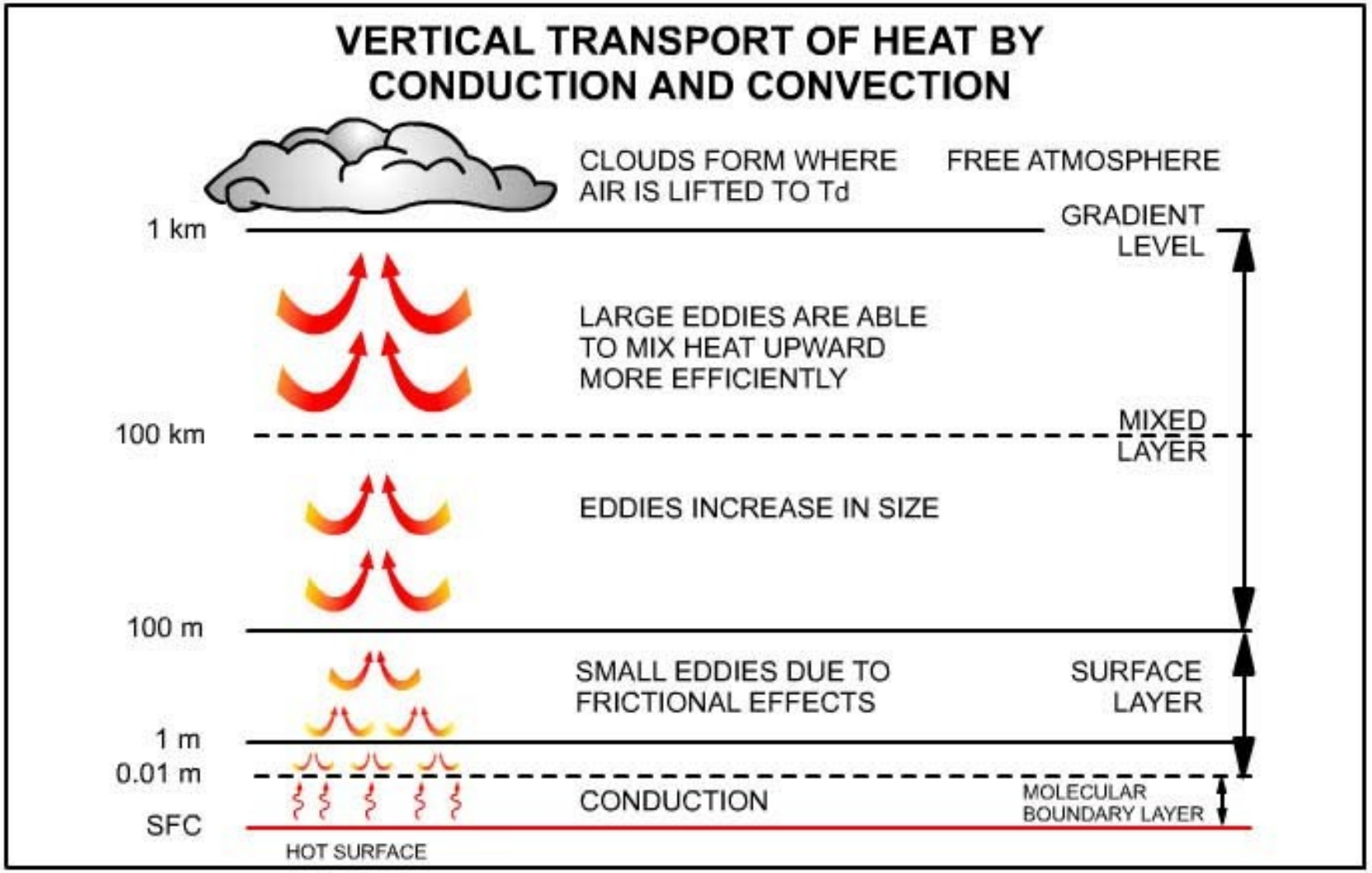
- Strong vertical mixing occurs in the troposphere.
  - Mechanical turbulence
    - Mixing due to frictional effects of the surface of the earth.
    - Strength depends on
      - surface roughness (terrain features, buildings, etc.)
      - wind speed (faster winds cause more mechanical turbulence)
      - stability - the more unstable, the more turbulence.
  - Thermal turbulence - due to surface heating.

Layers of the Atmosphere

- Air molecules travel through the depth of the troposphere in a few days (in thunderstorms it occurs over a few minutes).
- Solid particles remain in the troposphere for only a few days to a week due to rapid mixing and precipitation.
- The absorption of terrestrial radiation by water vapor and carbon dioxide (Greenhouse effect) and the transfer of latent and sensible heat from the earth's surface is the primary heat source.

Layers of the Atmosphere

- Layers of the troposphere
  - Planetary Boundary Layer (PBL)-friction layer
    - The portion of the atmosphere affected by the friction of the earth's surface (also called boundary layer).
    - The height of the PBL extends from the surface to the gradient level where friction is negligible and the wind blows parallel to the contours (i.e., geostrophic wind).
    - The height of the PBL is dependent on wind speed, terrain, and stability.


VERTICAL TRANSPORT OF HEAT BY
CONDUCTION AND CONVECTION
CLOUDS FORM WHERE
AIR IS LIFTED TO Td
FREE ATMOSPHERE
1 km
GRADIENT
LEVEL
LARGE EDDIES ARE ABLE
TO MIX HEAT UPWARD
MORE EFFICIENTLY
100 km
MIXED
LAYER
EDDIES INCREASE IN SIZE
100 m
SMALL EDDIES DUE TO
FRICTIONAL EFFECTS
SURFACE
LAYER
1 m
0.01 m
CONDUCTION
MOLECULAR
BOUNDARY LAYER
SFC
HOT SURFACE

Layers of the Atmosphere

- Parts of the planetary boundary layer:
  - » Molecular boundary layer (MBL) - extends from the surface to 1 cm. Mixing is completely suppressed. Conduction is the primary method of heat transfer.
  - » Surface Layer - extends to approximately 10 m and where microscale mixing occurs.
  - » Mixed layer - extends to about 1 km and where greater mixing takes place, but is still affected by friction.

Layers of the Atmosphere

- Free Atmosphere - above the boundary layer and extends through the rest of the troposphere and upward to the top of the atmosphere.

Layers of the Atmosphere

- Tropopause (10 - 20 km altitude)
  - It is the transition from troposphere to stratosphere.
  - Acts as a ceiling for most weather in the troposphere.
  - The height is lower in polar regions and higher in equatorial regions.
  - The height of the tropopause changes dramatically across the mid-latitude jet stream (i.e., a strong river of air in the upper troposphere).

Layers of the Atmosphere

- Stratosphere - means "layered sphere"
  - Extends from 20 km to 47 km.
  - Extremely stable. Temperature profile displays an inversion.
    - Very little mixing occurs between the stratosphere and the troposphere.
    - Strong thunderstorms can penetrate only a few km into the stratosphere (overshooting tops).
  - Mixing is suppressed because of the stability.
  - Particles can remain in the stratosphere on the order of **years.**

Layers of the Atmosphere

- Debris from past nuclear explosions and dust from volcanic eruptions are present in much higher concentrations than in the troposphere.
- The highest concentration of stratospheric ozone is seen between 20 and 25 km.
- Absorption of solar radiation by ozone is the primary heat source.
- Accounts for approximately 20% of the atmospheric mass.

Layers of the Atmosphere

- The troposphere and stratosphere combined account for 99.9% of the atmosphere's mass.
- The top of the stratosphere is near the 1 mb level.

Layers of the Atmosphere

- The stratopause is the transition from the stratosphere to the mesosphere. (47 km to 55 km.)

Layers of the Atmosphere

- Mesosphere - means "middle sphere"
  - Extends from 55 km to 78 km.
  - The top of the mesosphere is near 0.01 mb.
  - Accounts for 0.099% (approximately 1/10%) of the atmosphere's mass.
  - Temperature decreases with height (positive lapse rate).
  - Vertical motions are not suppressed.

Layers of the Atmosphere

- Unstable, but there's so little atmospheric mass to lift, that there is no weather.

Layers of the Atmosphere

- Mesopause is the transition from mesosphere to the thermosphere (78 km to 98 km).

Layers of the Atmosphere

- Thermosphere (heat sphere)
  - Extends from 98 to 500 km.
  - Temperatures increase with height (negative lapse rate).
  - Temperatures range from 500°K to 2000°K and are directly proportional to the amount of solar activity.
  - Heat source is the absorption of solar radiation by molecular oxygen (O_2).

- APPLICATION: Assign Review Exercise in WB-100
- EVALUATION: Administer and evaluate Appraisal 102a. Give the written test at the end of the unit.